6 Practical 2

Investigating the rate of respiration of small organisms using a simple respirometer

Safety

The normal safety precautions associated with the use of chemicals apply. Soda lime is corrosive: if it is spilled on skin, wash it off immediately. Eye protection must be worn.

Students should wash their hands after handling biological material.

Apparatus and materials

- two 10 cm³ plastic syringes with short lengths of rubber tubing attached
- two 20 cm lengths of glass capillary tubing of known internal diameter
- water bath (trough or wide beaker)
- small beaker of manometer fluid (coloured water containing a drop of detergent)
- marker pen
- stopwatch
- paper tissues
- two bags of soda lime wrapped in muslin to fit inside syringe
- maggots, mealworms or germinating mung beans
- balance weighing to at least 0.01 g
- ruler
- blunt forceps
- aluminium foil

Introduction

A respirometer can be used to measure the rate of uptake of oxygen by small organisms, such as insects or germinating seeds. There are several different designs of respirometer. In this simple version, the organisms are placed in the barrel of a syringe (Figure 6.1).

As the organisms respire, they use up oxygen. Any carbon dioxide produced is absorbed by soda lime. The rate of uptake of oxygen can be found from the rate of movement of the fluid in the capillary tube.

In this practical, you will:

- measure the rate of respiration (part A of the procedure)
- find the effect of a change in temperature on the rate (part B).
Procedure

A  Measuring the rate of respiration

1  Select some small living organisms, such as maggots, mealworms or germinating mung beans. Check that they will fit comfortably into the barrel of a syringe, as shown in Figure 6.1. Weigh the organisms on a piece of aluminium foil.

2  Place some soda lime wrapped in muslin in the bottom of the barrel of the syringe. Introduce the organisms that you have weighed into the syringe. Now carefully insert the plunger about half way down the syringe.

3  Attach a length of glass capillary tube to the rubber tubing on the syringe. Place the respirometer on the bench for about two minutes. Dip the end of the capillary tubing into the beaker of manometer fluid. A small amount of coloured water will enter the capillary tube to make the respirometer shown in Figure 6.1. This is your experimental respirometer.

4  Place the respirometer horizontally on the bench and mark the position of the meniscus in the glass capillary tube. Start a stopwatch.

5  Prepare another respirometer with the same mass of soda lime but do not add any organisms. This respirometer is your control. Mark the position of the meniscus in the same way as in step 4. Note the time.

6  After 5 minutes, mark the new position of the meniscus in the experimental respirometer tube (if 5 minutes is not sufficient, wait for a suitable length of time). Similarly record any movement of the meniscus in the control respirometer.

7  From these readings, calculate the volume of oxygen used by the organisms. If the internal radius of the capillary tube (r) is known, the volume is found from the formula:

\[ \text{volume of oxygen used} = \text{distance moved by meniscus} \times \pi r^2 \]

8  Now find the volume of oxygen used per unit mass of organisms per minute, using the formula:

\[ \text{volume of oxygen used per gram per minute} = \frac{\text{total volume of oxygen used (from step 7)}}{\text{mass of organisms (in grams)}} \times 5 \text{ minutes} \]

9  a  What are the advantages of using this method of measuring rates of respiration, and what are its limitations?
   b  How should you use the readings from the control respirometer?

B  Changing the temperature

1  Measure the rate of respiration of the organisms at two temperatures within the physiological range, such as 20 °C and 30 °C. Carry out the investigation as described above, but place the barrel of the syringe in a trough or wide beaker of water at the chosen temperature.

2  What effect did a change of temperature have on the rate of respiration of the organisms? Explain why temperature affects their metabolism.